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THE OUTBREAK OF
PSEUDOCOCCUS SACCHARI, Ckll.,
ON THE SUGAR CANE OF EGYPT.

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STATISTICS OF SUGAR CANE CULTIVATION, YEARS 1910-1921.

PROVINCES.

PROVINCES.	AREA UNDER CROP IN FEDDANS.							1919-20	1920-21
	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17		
Beheira ...	841	401	399	310	466	777	782	873	701
Gharbiya ...	780	414	355	413	499	716	788	1,022	751
Daqahliya ...	593	316	294	507	533	784	683	524	524
Sharqiya ...	474	406	380	339	528	616	808	634	634
Minufiya ...	636	444	423	387	538	640	906	835	658
Qalyubiya ...	487	426	376	334	403	686	914	767	591
LOWER EGYPT ...	3,811	2,407	2,227	2,290	2,967	4,219	4,881	4,820	4,060
Giza ...	775	985	957	560	930	1,422	2,183	1,763	1,076
Beni Suef ...	342	416	388	176	355	548	347	354	286
Faiyūm ...	411	347	528	509	492	726	528	627	168
Minya ...	7,329	7,118	7,778	8,396	9,543	9,306	7,757	8,444	7,764
MIDDLE EGYPT ...	8,857	8,866	9,651	9,641	11,320	12,002	10,815	11,016	9,753
Asyût ...	8,892	11,036	11,352	9,470	11,759	11,810	10,574	11,202	10,401
Girga ...	2,416	2,334	1,284	1,203	1,190	1,507	1,857	1,891	1,815
Qena ...	18,242	20,739	19,634	21,189	2,2101	23,410	27,620	28,502	25,164
Aswân ...	3,381	4,647	4,320	4,416	2,844	6,276	6,482	6,144	5,946
UPPER EGYPT ...	32,931	38,756	36,590	36,278	37,894	43,003	46,533	47,739	43,326
ALL EGYPT ...	45,599	50,029	48,468	48,209	52,181	59,224	62,229	63,575	57,139

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THE OUTBREAK OF PSEUDOCOCCUS SACCHARI, Ckll., ON THE SUGAR CANE OF EGYPT.

The sugar cane cultivation of Egypt dates back to 1848, in which year Ibrahim Pasha introduced a red variety from Jamaica : the variety now known as "Baladi." The experiment met with such success that a factory was built at Roda in 1855 to extract the sugar from the cane, and so profitable did it prove that the area under sugar cane increased yearly. Sugar cane is now one of the major crops of Egypt and the old Roda factory has long since been replaced by six or seven others of more modern type situated at intervals throughout Upper Egypt. The sugar production of Egypt at the present time is practically a monopoly of the Société Générale des Sucreries et Raffinerie d'Egypte and all the factories with one exception belong to them.

In 1903, owing to the low market price of sugar, the low production of "Baladi" cane, and the high prices obtained by other crops, it was realized that unless a higher producing cane was found the future of sugar production in Egypt was doomed. Accordingly M. Henri Naus Bey of the Sugar Company visited Java, Borneo, Hawaii, etc., and brought back 128 selected varieties of sugar cane. Amongst these was found a variety called "Java 105" which possessed the necessary characteristics for revitalizing the industry.

It might be as well here to compare "Baladi" and "105," the two varieties almost exclusively grown in Egypt to-day.

Although "105" cane contains a slightly lower sugar percentage—12·5 to 13 as against 13·5 to 14—and a slightly lower degree of purity, it has the characteristic of giving a much higher yield of cane per feddân than the "Baladi." In the first year it produces about 200 qantârs per feddân* more cane and whereas in the second year the yield per feddân only falls off by 100–150 qantârs, in the case of "Baladi"

* 1 qantâr = 44·928 kilos. = 99·05 lbs.

1 feddân = 4,200·893 square metres = 5,024·17 square yards = 1·038 acres.

it falls off from 150–200 qantârs, so that over a period of two years a field will produce 400 qantârs per feddân more cane or an increased yield of over 30 per cent. On well cultivated good land "105" will give in the neighbourhood of 900 qantârs, and it has an additional advantage in that it will produce a remunerative crop on poor land.

This increase in production of the "105" variety over the "Baladi" is due to the fact that the former grows much more slowly than the latter in the early stages and some of the lower eyes grow out giving a greater number of canes per set planted. On the other hand "Baladi" cane is stouter and finer in appearance.

The "105" cane, however, possesses one serious drawback, once the cane is cut inversion of the sugars rapidly sets in. Consequently it has to be passed to the factory after cutting with the utmost despatch, a delay of more than twenty-four hours being sufficient to reduce the available crystallizable sugar content.

Sugar cane is grown in Egypt for three purposes:—

- (1) Human consumption (chewing).
- (2) "Honey" manufactured in the villages for local consumption.
- (3) Sugar production.

By far the most important of these is the sugar production and it is chiefly with sugar cane grown for this purpose that the present paper deals.

The attached table shows the areas under sugar cane cultivation for the last ten years, and it will be seen that the Provinces of Minya, Asyût, Qena, and Aswân claim by far the greatest areas. These are the provinces served by the factories of the Sugar Company; the other provinces, with the exception of Girga, only produce cane for human consumption (chewing).

The chief localities under sugar cane in the various provinces and the factories by which they are served are as follows:—

PROVINCE.	LOCALITY.	FACTORY SERVED BY.
Minya	{ Sheikh Fadl Maghagha Beni Mazar	{ Sheikh Fadl.
Asyût	Mallawi	Abu Qurqâs.
Girga	Balyâna	Balyâna.
Qena	Nag Hamâdi	Nag Hamâdi.
Aswân	{ Armant Mataana Kôm Ombo	{ Armant. Kôm Ombo.

The only factory not belonging to the Sugar Company is a small one at Balyâna. This belongs to a certain family of big land-owners at Balyâna who supply it with sugar cane of their cultivation.

Reference to the table will show that the total average acreage under cultivation is in the neighbourhood of 57,000 feddâns producing about 40,000,000 qantârs of cane yearly. The average yield per feddân is about 650 qantârs, but that depends on the variety of cane grown, and as our statistics of the average yield per feddân are compiled irrespective of the variety and the percentage of first, second, and third year growth, they are misleading for the purposes of the present paper and have been omitted.

The Sugar Company absorb more than two-thirds of the total crop, although with the exception of a few thousand feddâns at Nag Hamâdi they cultivate practically no land themselves. The cane is bought from the cultivators under contract at a fixed price of P.T. $9\frac{1}{2}$ per qantâr for 1921–1922 and P.T. 6 for the coming season of 1922–1923.

It is not so much the cultivation of sugar cane as the manufacture of sugar from the cane that has received such a severe set-back from the ravages of the Sugar Cane Mealy Bug —*Pseudococcus sacchari* CKLL.— indeed such a setback that the whole future of the industry hangs in the balance.

Pseudococcus sacchari CKLL. is a mealy-bug of world wide distribution and was known in Egypt as far back as 1912. It was not, however, until the end of the war that it came into prominence, and from 1918 to the present time it has increased to such an extent that the whole sugar cane crop of Egypt is infected to a greater or lesser degree. Unfortunately by far the worst attack is at Nag Hamâdi, the biggest area under sugar cane cultivation. The other areas are already bad, and they will become considerably worse if measures are not taken to arrest the outbreak. Kôm Ombo is probably the most lightly attacked, but the cane there suffers from lack of land drainage which gives rise to very irregular growth.

The two main reasons for the outbreak are :—

- (1) Bad cultivation during the war.
- (2) The introduction of the “ 105 ” Java cane.

(1) Prior to 1914 the fuel used in the sugar factories was coal, but during the war the price rose to such heights that its use became economically unsound. Consequently it was replaced by trash, i.e. the leaves and refuse from the fields. This trash, which contains millions of living insects, is conveyed loose either by trucks or other means of transport from all parts of the sugar growing area to the factories. Some of this is unavoidably dropped or blown off and the

whole track becomes strewn with leaves from which the insects crawl on to the adjacent standing cane, thereby steadily distributing and increasing the infection. There is at least four months between the time the first consignment of trash is conveyed to the factory and the last field harvested, so that insects from the first consignment may have up to four months in which to increase the infection on already infected cane.

Further, as the price of sugar rose during the war, the area under cultivation increased and the cultivation became worse and worse : poor quality " sets " were planted and no trouble was taken to remove the leaf sheaths from the " sets " before planting. Cane was ratooned four and five times and cane followed cane on the same land year after year. No attempt was made to clean up the fields after the harvest until quite recently, and this bad cultivation during the war together with the removal of trash from the fields has undoubtedly been largely responsible for the outbreak.

(2) In comparing " Baladi " and " 105 " cane one characteristic was omitted ; the leaf sheaths of the former are not so closely adherent to the parent cane as in the latter and the lower sheaths tend to come away from the parent cane and break off clean at the node. The insect therefore cannot get the same shelter as is afforded by the closely adhering leaf sheaths of the " 105 " and consequently does not find the " Baladi " cane quite such a congenial breeding ground. For this reason the former variety does not become so heavily infected as the latter.

It has already been pointed out that " 105 " cane was first introduced in 1903, but it was not until 1909 that the Sugar Company authorized the cultivators to plant out " 105 " cane. Permission was first granted to introduce 25 per cent and this was later increased to a maximum of 50 per cent. In spite of this limit the cultivators developed the variety to such an extent that, in 1915, 95 per cent of the cane passed to the factories was " 105 ." This gradual replacement of the " Baladi " variety by the " 105," whilst admittedly essential to save the industry, has undoubtedly favoured the increase of *Pseudococcus sacchari* CKLL.

The cultivation of " Baladi " cane for human consumption still continues owing to its slightly higher sugar content, and the fact that it is a finer cane. About 500 feddâns per province are cultivated for this purpose and the price obtained for the first year crop is such as to more than counterbalance the lowered yield of the second year.

DESCRIPTION AND HABITS OF THE INSECT.

The adult female is large, elongated, ovate, decidedly plump, and delicate pink in colour ; it is only very sparsely mealy and the

segmentation of the abdomen is apparent. Marginal filaments are wanting. It is ovo-viviparous and gives rise to a little very loose white fibrous secretory matter and much "honey dew." The female is only active normally in its young stages, but it retains the power of locomotion throughout life.

Length of adult female 6 to 10 millimetres. Breadth 3 to 5 millimetres. The male does occur in small numbers, but is not of any economic importance and may be disregarded.

The adult female produces living young parthenogenetically, *i.e.* without the intervention of the male. The fact that there is no ovisac or external eggstage is one of considerable importance in connection with the control of the pest.

The position favoured by the insects on the cane is that immediately below the node where they are sheltered by the close adherence of the leaf sheath arising from the node below. Any tendency towards movement is always directed to a higher node where more tender growth is to be found; the young females shortly after birth migrate to the next node or to some higher node where they settle down to feed and normally complete their life-cycle without a further change of position. Migration to the most tender growth near the growing point is prohibited by the extremely close adherence of the leaf sheaths beneath which the insects are unable to penetrate and find shelter. The only insects ever found at a place other than immediately below the node are those young females migrating to a more congenial feeding place in which to complete their life-cycle.

NATURE OF DAMAGE.

The insects feed by inserting a long sucking tube into the host-plant and withdrawing the plant juices. The result of thousands of these insects at work is the production of gum on the outer surface of the cane. This sticky secretion is formed partly by the exudations (honey dew) which are invariably associated with large colonies of any mealy bug and partly by the exudations from the cane, a defensive measure induced by the wounds caused by the insertion of the long sucking tubes. This gummy mixture tends to move downwards so that in heavily infected canes all the internodal surface of the cane becomes coated and it collects just above the node where it is held in place by the leaf sheath arising from that node. I may point out here that this gumming makes it very difficult to strip the canes of their leaf sheaths and, as the "105" variety is normally more difficult to strip than the "Baladi," cultivators are obliged to employ more labour for this operation.

I have been struck by the fact that the amount of gum varied in different fields in spite of a similar intensity of attack. I think we may assume that the "honey dew" produced by any given number of healthy insects under similar conditions is approximately the same and the variation must therefore be due to variations in the quantity of the exudations from the cane. It seemed that the healthiest and finest canes produced the most gum, and it may be that as the exudation from the cane, is a defensive weapon, a healthy cane is better equipped for the fight and consequently produces more gum. On the other hand it may be due to variations in the cane induced by chemical differences of the soil on which the cane is grown. This requires further investigation. The relation of sap flow and irrigation to gumming is another line of research that would give interesting results.

Not only does the insect impair the health of the cane but indirectly through the production of gum it has very far reaching results upon the available sugar content. It is found that when infected canes are crushed and passed through the factory, the crystallizable sugar content is much reduced. How far this is actually due to the presence of the gum and how far to subtle changes induced within the cane I am not in a position to state. A very simple experiment proved that the "honey dew" reduced and even inhibited crystallization, and in any case the reduction in sugar output is traceable to the ravages of the insect.

The gravity of the situation from a commercial standpoint is obvious. All the cane passed through the factories is gummy to a greater or lesser degree and not only is such cane far more difficult to work, but the percentage of crystallizable sugar obtained is so reduced as to entail a loss to the Sugar Company of hundreds of thousands of pounds.

SUGGESTED CONTROL MEASURES.

The nature of sugar cane is such that it is impossible to carry out any prophylactic measures whilst the cane is growing in the field. It might be possible to remove the gum from the canes, assuming that the gum alone is responsible for the reduced sugar output, but this would be by no means easy and when one realizes that the factory at Nag Hamâdi deals with over a million canes daily it is difficult to see how it could be carried out practically. It is much more sound to deal with the cause than to pay attention to the effect of the attack, and the most effective lines of control are those directed to the "sets" planted and to the methods of cultivation.

I will proceed now to discuss in detail the various control measures suggested.

1. CLEAN "SETS" MUST BE PLANTED.

The method of planting usually adopted in this country is to plant lengths of cane about 18 inches (46 centimetres) long in pairs, the pairs lying end to end and about 6 inches (15 centimetres) below the level of the ground. At the present time it is practically impossible to obtain cane for planting that does not carry living insects, and every field planted is infected from the very start. If it is possible, however, to so treat the "sets" before planting that all the insects are killed without impairing germination then that cane will grow up free from disease and any infection which appears subsequently will have been derived from external sources.

A series of experiments was carried out to find a solution for the treatment of the "sets" which would not be too costly and yet meet the requirements. A number of different liquids were tried and in each case the "sets" were completely immersed.

(a) Hot water at a temperature of 60°C. only killed 10 per cent of the insects and it failed to dissolve the wax or fibroid material.

(b) Cyllin. Solutions of 3, 5, and 10 per cent were tried and the mortality in each case was about 60 per cent. The wax appeared to be partially dissolved, but the fibroid material was untouched. Cyllin made up with hot water was also not fully effective.

(c) Lysol. 3, 5, and 10 per cent gave the same results as in the case of Cyllin.

(d) Clensel gave the same results as Lysol and Cyllin.

(e) Carbon Bisulphide. This was very effective. Immersions for twenty seconds killed every insect, but it is unsatisfactory owing to the fact that it is expensive and extremely inflammable. It would be dangerous to handle in large quantities.

(f) Paraffin emulsion. This gave excellent results. The stock solution was tried at various dilutions and it was found that a dilution of one in thirty killed every insect if the set was immersed for two minutes. This solution dissolves the wax, has a good wetting power, and kills 100 per cent of the insects.

The proportions of the ingredients in the stock solution are as follows :—

Paraffin or petroleum	...	...	...	...	...	2 gallons.
Water...	...	...	...	...	...	1 gallon.
Sunlight soap	...	...	...	...	...	1 lb.

The soap in this solution is double the amount used in the normal solution in order to increase the wetting power.

“ Sets ” immersed take up a darkish green hue and when on emergence they cease to have this hue it is time the solution should be reinforced. The solution will last for an hour to an hour and a half if it is constantly in use without the addition of further stock solution. At the present price of paraffin the cost of treatment comes to about P.T. 100 per feddân, including the cost of extra labour. This is rather expensive, but as the value of a feddân of sugar cane varies from L.E. 60 to L.E. 80, it is not more than an insurance of $1\frac{1}{2}$ per cent and the cultivators would get this back, and considerably more, in the increased yield per feddân.

The chief objection to the use of paraffin emulsion is the difficulty of preparing it ; unless it is correctly made up it is useless. Suggestions for surmounting this difficulty will be found on a later page. It is hoped that another solution may be found which will remove this obstacle, but for the present no success has been met with.

It is important to remember that immersion is of no avail unless the “ sets ” are completely stripped of all leaf sheaths. The insects lie hidden beneath the leaf sheaths and no solution will penetrate there and kill the insects. The leaf sheaths, then, must all be removed, and this process must be not carried out on the field to be planted out. The stripping should be done in the field of origin of the cane and the “ sets ” brought to the field of planting, dipped, and sown. It is needless to point out the danger of stripping the canes of their infected leaf sheaths on the field about to be planted.

I cannot lay too much stress on the importance of the planting of clean “ sets.” Once we start with clean cane in our fields it should not be so difficult to keep it clean and the remaining suggestions are subsidiary and designed for this purpose. *The crux of the whole problem, however, lies in the sowing of clean “ sets.”*

2. CANE SHOULD ONLY BE GROWN FOR TWO YEARS ON ANY FIELD UNTIL THE PEST IS UNDER CONTROL.

The expense of cultivation makes it a great temptation for the cultivator to leave his cane in and ratoon three or four times, the limiting factor being the reduced yield. In Barbadoes sugar cane is a one-year crop and in the West Indies generally ratooning does not usually take place more than once or twice. It is true there are other reasons for this, but with the severity of our present outbreak it is high time that ratooning should be limited to once and certainly never more than twice. The yield steadily deteriorates as the years proceed and the insect attack steadily increases. How far the reduction in yield is directly attributable to the insect attack it is

difficult to say, but there is no doubt that the insect is largely responsible for it. Until such time as the pest is under control it will be wise only to grow cane on any one field for two years. It may be pointed out that the yield per feddân of third, fourth, and fifth year cane is such that it is hardly profitable and making cane a two-year crop would not be any great hardship to the cultivator.

3. THE "TRASH" NOT TO BE USED IN THE FACTORIES AS FUEL.

Attention has already been drawn to this. I would suggest that if it is essential for the Company to use "trash" as a fuel that, instead of transporting it loose, it might be compressed into bales. Portable presses can be bought at a low figure and readily used in the fields. This method would have the additional advantage that a far greater weight of "trash" per truck could be transported. I do not advise this method, but it would be preferable to the existing practice. Now that the price of coal has fallen practically to pre-war rates I see no reason why the use of coal should not be resumed.

Another alternative is to grow Sessaban (*Sesbania aegyptiaca*) around the fields. Sessaban has quite a high calorific value, grows moderately rapidly and requires no attention. At Armant it is grown for use in the factory, and this is a practice that might well be adopted more generally.

4. THE LAND SHOULD BE THOROUGHLY CLEANED IMMEDIATELY AFTER THE HARVEST.

The present system is to remove the great majority of the "trash" to the factories and villages and then to burn over the land. No "trash" should be removed from the field; the whole should be thoroughly burnt. This would account for a very high percentage of the insect population and would remove one of the most favourable methods of distribution.

5. CANE SHOULD NOT BE GROWN ON CANE.

During the war cane was frequently grown after cane on the same land, and although it is not now so prevalent I have met with many cases. Apart from any agricultural considerations it is a practice which militates against the control of the pest by carrying on the infection. It would be of very little value to plant clean "sets" on land from which cane had only recently been removed, there would always be sufficient infection, however, well the land had been cleaned, to reinfect the new crop.

An experiment was carried out at Nag Hamâdi last winter on a large scale by the Sugar Company in which "sets" treated in emulsions of mazoot and paraffin of varying dilutions and for varying times were planted out. The field chosen was planted out at the beginning of October and was land which had borne cane for the previous three years, the last crop having been harvested the previous April. This land was not properly worked over until shortly before planting, thus providing the insects sufficient food to carry on until the new "sets" were planted. When I examined the field early in December 75 per cent of the young shoots were infected. In two small plots the "sets" had been dipped in pure paraffin and mazoot respectively, only one per cent of these had germinated; but even they were found to carry living insects. This is conclusive proof that the insects had reinfected the canes subsequent to planting. It was unfortunate that such a field should have been selected for so elaborate an experiment as any results obtained are not only valueless but actually misleading. I may add that I also found in many cases that the "sets" had not been thoroughly stripped of leaf sheaths, thereby affording the insects shelter during immersion.

The planting of cane in October is unusual and should be discouraged from the outset. Cane thus planted is cut in January or February year, *i.e.* after a growing period of sixteen months. This is bad for insect control, affording as it does a longer period for the insect in which to breed and work its ravages. Also it does not appear very economical as the land is occupied for the better part of two years to give only one cutting. The normal time for planting out is from March to May and for cutting from December to March.

After the land, then, has been under cane for two years (one ratooning) it should be given a rest for at least one year and may during this time be planted out with any other crop at the discretion of the owner. This enables the land to free itself of all infection before the next crop is planted.

I have not yet found *Pseudococcus sacchari* CKLL. on any other crop or weeds around the field. Halfa grass, which is prevalent everywhere, does not appear to be infected; it would be a very serious stumbling block to the control had it proved susceptible. The only other host plant I have yet found is that known as "Heesh": *Saccharum biflorum* or *oegyptiacum*. This plant, which grows along certain canals and on waste spaces, is thought to be the original ancestor of our present cultivated sugar cane, so it is not altogether unexpected that *Pseudococcus sacchari* CKLL. should bestow its attentions upon it. Fortunately "Heesh" is not frequently found in the neighbourhood of the sugar cane fields and so the attack on this grass need hardly be considered in connection with the control of the outbreak on the sugar cane.

6. AS FAR AS POSSIBLE BIG AREAS SHOULD BE PLANTED WITH CANE AND THERE SHOULD NOT BE SMALL AREAS OF CANE OF DIFFERENT YEARS INTERMIXED WITH OTHER CROPS.

Second year cane is naturally more heavily infected than first year cane and the risk of infecting first year cane where the "sets" have been treated is great if that cane is in close proximity to infected second year cane.

First, second, and possibly third year cane in close proximity means that there is an endless chain of infection which it is very difficult to combat by any control measures and thus it would be advisable as far as possible to grow cane in big areas. Every third year the land would then be occupied by some other crop and a break in the sequence of host plants for the insect effected.

Summarizing the foregoing control measures I would suggest that :—

- (1) Clean "sets" be planted.
- (2) Cane should only be grown for two years on any field until the pest is under control.
- (3) The "trash" should not be removed from the fields or used by the factories as fuel.
- (4) The land should be thoroughly cleaned immediately after the harvest.
- (5) Cane should not be grown on cane.
- (6) As far as possible big areas should be planted with cane.

I should have liked also to suggest that the growth of "Baladi" cane be encouraged, but that is hardly practical. The cultivator could not be expected to comply with this owing to its low yield ; it would not be worth his while to cultivate "Baladi" cane at the current price per qantâr offered by the Sugar Company. This, however, is not at all essential if the suggestions put forward for the control of the outbreak are adopted.

SUGGESTED METHOD OF APPLICATION OF THE
CONTROL MEASURES.

Early this year an attempt was made to induce cultivators to exercise control measures by propaganda, and they were circularized with a pamphlet pointing out the dangers to the crop and the steps to take. The Government further undertook to supply any cultivator with the necessary paraffin emulsion at cost price. This campaign did not prove a success.

In dealing with a problem of this nature the control measures must be universally adopted to meet with full success, otherwise the cultivator who carries them out is penalized by his neighbour who does not. I estimate that, if the recommendations were adopted generally, the pest would be well under control in three or at the outside four years and that certain of the measures could then be relaxed.

It is not easy to devise a satisfactory practical method for the application of these control measures, and it is impossible unless the Sugar Company co-operates with the Government. The Sugar Company has everything to gain by such co-operation ; the cultivator, on the other hand, will not be quite so easily convinced at first, owing to the fact that it costs a little and sugar cane is not such a very profitable crop to him. After the first year, when he realizes that he recovers more than his outlay in the increased yield per feddān, it will be easy.

The chief difficulty is how the cultivator is to obtain clean "sets." No cultivator, with the best intentions in the world could do this for himself without assistance, and I suggest that it should be made possible for him to obtain guaranteed clean "sets" at cost price. The Sugar Company could provide these by growing the necessary cane on their own land and, treating and distributing them from their factories against demand. Indeed I would go further. I suggest that the reduced price paid for the cane by the Company is placing the onus of this outbreak on the cultivators. The cultivator is not altogether responsible for the outbreak and with the low price prevailing it is doubtful if much new cane will be planted, and it will be extremely difficult to convince him of the advisability of paying for the control measures. Therefore I suggest that the Sugar Company might either provide the clean "sets" free of charge or increase the price paid for clean cane. One cannot expect the cultivator to bear the brunt of both the outbreak and the control measures. It would pay the Company a hundredfold to provide clean "sets" free of charge to cultivators ; P.T. 6 per qantār is an extremely low figure for the clean cane which they would get back in return and the profit that would accrue on that score would more than counterbalance the expenditure in the provision of clean "sets."

The actual execution of this proposal would not, I think, present any serious difficulties to the Company, and the Government might, I suggest, step in and by law decree that no "sets" other than those bought or obtained from, and certified clean by, the Sugar Company might be planted in the big sugar cane growing areas.

The objection may be raised that not all the cane grown in the big areas finds its way to the factories. That is correct, but it would not cost the Company anything beyond a little extra trouble to provide

“sets” for all and the control of the pest is at stake which means everything to them. “Sets” issued to cultivators not supplying the Company would, of course, have to be paid for.

Another point that may suggest itself is that the planting of any field is dependent on the arrival of the water supply, and the cultivator cannot tell until a few days before when he will plant out. Consequently it may occur that prepared “sets” are held up for a week or two before planting. The inversion of the sugars which takes place so rapidly in the “105” cane does not affect the germinating capacity; the “sets” will survive for considerably longer than two weeks, so that a slight delay in planting out need be no cause for alarm.

Assuming, then, that the Sugar Company provided clean “sets” and the Government laid down by law that only such “sets” were to be planted, the main control measure would be enforced. The other measures, with the exception of No. 6, could also be included in the law and their execution would not prove any hardship to the cultivator except in so far as he would be deprived of the “trash” for fuel.

Recommendation No. 6 would not be easy to enforce, but it might be effected by the judicial arrangement of the contracts entered into by the Company with the cultivators. It would take at least two years to carry out without imposing too great restrictions on the cultivator and would need very careful working out.

NATURAL ENEMIES.

Only two natural enemies have been found to be of any assistance in the control: the rat and a fungus.

(1) In every area inspected last winter I noticed that on heavily infected canes a part of the leaf sheath immediately below the node would be torn away and the parent cane revealed. These “windows,” so to speak, were always in exactly the same place, just below the node, and no insects were ever found on the surface of the cane thus exposed although obviously insects had been present. Many such “windows” were found on a heavily infected cane, sometimes as many as nine or ten.

Whatever makes these windows must be feeding on the insects because:—

(a) Canes not infected have no such “windows.”

(b) The “windows” are always in the same relative position on the cane, *i.e.* immediately below the node where the insects invariably congregate. If the animal wanted the gum it would make the windows immediately *above* the node.

(c) Canes on which the insects have already been killed by fungus possess only very small peep holes, as if the animal finding the insects dead has gone elsewhere.

(d) Where there is a "window" there are never any insects on the exposed surface of the parent cane, but on lifting back the remainder of the leaf sheath the insects are found on either side of the "window." The animal, therefore, can only get at the insects where it has torn away the leaf sheath.

(e) Scratches are found on the surface of the cane such as might be made by the teeth of an animal in removing the insects.

There is very little doubt that the rat is responsible for these windows as rats are abundant in the fields. Indeed it is difficult to see what else it would be. On one inspection rats were seen high up on the cane, and an examination of the cane showed that the rats had just been disturbed whilst in the act of making the "windows." The stalks of the canes were only found bitten through by rats where they were uninfected or only very slightly infected, and it appears that the rat has a very decided partiality for a diet of this particular insect.

This can never constitute more than a subsidiary control as it does not come into action until the infection is heavy, but it certainly assists in preventing the attack from becoming overwhelming.

(2) There are two distinct fungoid attacks or possibly they may be two stages of the same fungus.

The more prevalent by far is a green fungus. An insect attacked by this appears at first rather more waxy than usual and short filaments bearing sporangia arise from the body of the attacked insect. These sporangia are at first white but rapidly turn yellow green and then grass green. The insect is killed very quickly and becomes a hard dark mass covered with the green fungoid growth. Insects of all sizes were found attacked by this fungus irrespective of whether they were isolated or in large colonies and all stages from one insect to every insect in a colony being attacked were observed. In some cases at least 50 per cent of the insects on a cane had been killed by this fungus.

The other fungus is white and commences by an opaque white film forming on the mother cane underneath the insect. In a colony this white matter increases, filling up the interstices between the individual members and then growing over them so that they become completely enveloped and present a soapy opaque white mass. All the insects have long since been killed and on breaking up the mass it is found to be green within. This fungus was found to attack colonies rather than individuals.

It appears that the green fungus grows directly on the insect, killing it, whilst the white fungus grows around it and death from suffocation ensues.

Mr. Briton-Jones, Mycologist to the Ministry of Agriculture, has very kindly examined the green fungus for me, but up to the present he has got no proof of its being definitely parasitic. He states that the fungus in question is *Aspergillus flavus* and that he found traces of *Aspergillus niger* associated with it. I have observed this latter fungus in small quantities on the cane myself, but as it does not appear to affect the insect I have disregarded it. Mr. Briton-Jones suggests that the medium for these fungi may be the "honey dew" secreted by the insects and that death may be brought about by the blocking of the glands and spiracles. If the "honey dew" were the medium I should expect to find the fungus growing on the gum which contains a high percentage of "honey dew." This, however, is not the case; I have only observed the fungi growing on and immediately around the insects.

Whether the "honey dew" proves to be the medium or not the fact remains that either directly or indirectly the death of an appreciable percentage of the insect population is effected.

This fungoid attack, like the work of the rat, can only be regarded as a subsidiary control because it only comes into action on heavily infected canes. It may assist in preventing the outbreak from getting completely out of hand, but it cannot be relied upon to exercise any effective control of the pest.

Aspergillus flavus is well known in the West Indies and elsewhere as exercising a controlling influence on the activities of *Pseudococcus sacchari* CKLL.

No other parasites, either animal or fungoid, were observed, with the exception of fly larvae of two different species that were found in very small numbers in one field. Unfortunately the attempts to breed these through were unsuccessful, but no doubt a further opportunity will occur later.

Ants were found to be fairly common, searching as usual for the "honey dew" of the mealy bug. *COLLEMBOLÆ* and *Phyllodromia treitliana* WERNER (BLATTIDÆ) were also observed, but it is improbable that these are of any economic importance in the control of the pest.

Arrangements have been made to import *Cryptolæmus montrouzieiri* MULS.—a COCCINELLID—from the South of France. This species of CRYPTOLAEMUS has proved itself elsewhere a predator of *Pseudococcus sacchari* CKLL. and other species of *Pseudococcus* and has been imported and bred in many countries for this purpose. It does not necessarily follow, however, that it will thrive in this country and, even if it does, it will take years to establish itself and make its presence felt. It is therefore of paramount importance that at present reliance for the control of this pest should not be placed on natural enemies, but that artificial measures should be introduced without delay.

CONCLUSION.

Sufficient has been said to indicate the extreme gravity of the outbreak to the cultivators of sugar cane in this country and the lines along which it is suggested that the control might be effected.

Finally, I must express my thanks to Mr. Laing, of the Imperial Bureau of Entomology, for very kindly identifying the insect as *Pseudococcus sacchari* CKLL., and to M. Henri Naus Bey and the managers and staffs of the Sugar Company for their unfailing courtesy and kindness in affording me every possible facility for the study of the problem.

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